promised are: K. von Zittel, Palæontology; M. de Bertrand, Structure of the Western Alps; A. Heim, Geology of the Environs of Zurich; A. Michel-Lévy, the Unification of Petrographical Nomenclature; E. Suess, Tectonic Geology. There will also be papers on glacial geology; and Captain Marshall Hall will submit a proposal for an international survey and record of glaciers.

At the Zurich meeting, however, papers and discussions will form but a comparatively small part of the work. Excursions have always played a prominent part in the arrangements for the various meetings; but hitherto they have been mainly made after the close of the Congress. At Zurich the Congress will practically divide into five excursion sections, starting on September 3, traversing the Alps in different directions, and all converging on Lugano, where the closing meeting will be held on September 14. These excursions would alone make the Zurich meeting memorable; they have been planned to include the most interesting districts of the Swiss Alps, and to facilitate the study of many intricate problems concerning the structure of the mountains and the petrographical nature of the rocks. After investigation of the northern flanking ranges of folded secondary rocks, the central crystalline zone will be crossed, and in some cases glacial phenomena can be well studied. Prof. Heim will conduct a party over the country which he has so well described, starting from St. Gall and crossing the Alps of Glarus, the Vorder Rhein, and the eastern Lepontine Alps; Prof. Schmidt will conduct the party from Schwtz over the St. Gotthard; Prof. Baltzer, starting at Lucerne, will take a line some miles further west; Prof. Schardt, starting at Bulle, will traverse the western end of the Bernese Alps and part of the Pennine Alps, and will reach Lugano by the Simplon. These four excursions are for pedestrians only, and those only are invited who are accustomed to long walks and climbing, hard beds, and frugal living. A more elaborate circular tour in the Alps will be conducted by MM. Ruffieux and Ruchonnet, of Lausaunne; this will traverse a wider district, and the work will be done with less fatigue. Profs. Renevier and Golliez will be the scientific directors of this tour.

Supplementary excursions will start from Lugano after September 14, one of which, conducted by Profs. Brückner, Du Pasquier, and Penck, will study the glacial phenomena of the Italian Lakes, thence by the Tyrol to Munich, and finally to the Lake of Constance.

Before the Congress there will be excursions in the Jura—five for pedestrians—as follows: French Jura, M. Schardt; Vaudois Jura, M. Jaccard; Bernese Jura, M. Rollier; Bâle and the Argovian Jura, M. C. Schmidt; Argovian Jura and Soleure, &c., M. Murlberg. There will also be a long circular tour in the Jura by MM. Ruffieux and Ruchonnet, with MM. Renevier and Gollitz as scientific directors; the latter part of this will be much devoted to glacial questions, and will therefore be preparatory to the special glacial excursion starting from Lugano.

Arrangements have been made for inclusive charges for all these excursions. For the pedestrian tours, they are 50 or 60 francs for the Jura excursion of five or six days each, and 300 francs for the circular Jura tour of fourteen days.

For the longer excursions in the Alps, after the Congress, the prices are from 150 to 250 francs for the pedestrian tours of eight to thirteen days, and 400 francs for the circular tour of thirteen days.

A guide-book to the various excursions is in preparation. This will contain about 300 pages of text, and will be amply illustrated by plates and sections; it will form a most useful handbook to the geology of Switzerland. A new geological map will also be published, on the scale of 1 : 500,000; this will be a reduction of the official maps of the Swiss Geological Survey, which is now completed.

Special guide-books to the important geological collections at Lausanne and Zurich are in preparation. As usual at such meetings, geological maps and other publications, photographs, specimens, &c., will be exhibited.

W. Topley.

THE DISCS OF JUPITER'S SATELLITES.

THE discussion which is now taking place between two well-known observers—namely, Profs. Pickering and Barnard—as to the forms which the satellites of the planet Jupiter assume at various times, is one not only of absorbing interest, but, moreover, of a nature somewhat delicate, for the bodies in question are so minute as to baffle any but the very best and trustworthy observers. Such observations, then, to be of any value at all, must be either made in the clearest of atmospheres with a moderately large aperture, or in a moderately clear atmosphere with a very large aperture. Considering these two conditions, one would doubtless think that the larger the instrument the more chance there would be of finding out the shape of a body, and with a very clear atmosphere in addition these chances would be very greatly increased. On the other hand, however, we have the facts still in our mind of Schiaparelli's wonderful observing powers, which enabled him to notice the doubling of the canals of Mars with his small aperture long before they were declared "double" by other observers. In this case one would have thought that such an observation would have been more easily observed with large apertures than with the small telescope which was at his disposal.

Let us, however, turn to the facts at hand with regard to the satellites that are now under discussion; but first a few words with regard to the instrumental equipment employed and the observing stations.

Prof. Pickering's observations have been made at the Observatory that is situated near Arequipa, in Peru, at an altitude of more than eight thousand feet, where the sky during a large part of the year is nearly cloudless. The telescope employed has shown that there is a remarkable degree of steadiness in the atmosphere, and night after night atmospheric conditions prevail, which, as he says, "occur only at rare intervals, *if ever*, in Cambridge." Several of the diffraction rings surrounding the brighter stars are visible, close doubles in which the components are much less than a second apart are readily separated, and powers can be constantly employed which are so high as to be *almost useless* in Cambridge. In fact, he says that in many researches the gain is as great as if the aperture were doubled. The aperture of the refractor employed is 13 inches.

Prof. Barnard has made his observations, on the other hand, with the now well-known 36-inch refractor of the Mount Hamilton Observatory, a description of which here would be unnecessary; suffice it to be mentioned that Prof. Burnham has increased the number of double stars by about 200 during his brief use of this instrument, most of which are beyond the reach of the majority of telescopes.

Turning now to the observations of the satellites themselves, we find the first account of Prof. Pickering's observations in the March number of *Astronomy and Astro-Physics* for the year 1892.

On October 8, a series of measurements was made of the diameters of the satellites. On the next evening it was noticed that the disc of the first was not circular but very elliptical. Early observations on the tenth confirmed the measurements made on the eighth, but after an examination of the other satellites the first was again measured, when, as Prof. Pickering says, "to my astonishment, instead of showing an elliptical disc, it showed one that was perfectly circular, precisely like the other satellites." He further goes on to say that the disc gradually began to lengthen again and assume the elliptical form. From these observations it was concluded that the first satellite had the form of a prolate spheroid or ellipsoid, or, in other words, was egg-shaped. A week later each of the other satellites had been recorded to some extent elliptical. Curious to relate, the three outer satellites, according to the observations, appeared *shortened* equatorially, not *lengthened*, showing that they did not seem to revolve round their minor axes.

It was not surprising to notice that Prof. Pickering was at first rather sceptical about the truth of these observations, and assuming that they might be produced optically or otherwise, he employed every method which would eliminate such ambiguity. These researches gave a negative result. It occurred to him, also, that the effects seen might be due to light and dark spots, suitably placed upon the surface, but during the time of the satellites' transits, and when they were about to disappear, no such spots were seen, although some surface markings on the first, third, and fourth satellites have been discovered.

The results to be gathered from the observations made up to this time may be summed up as follows:—

(1) The first satellite is a prolate ellipsoid revolving about one of its minor axes in a period of 13h. 3m.; and (2) the discs of the second, third, and fourth satellites at regular intervals assume the forms of ellipses, and these periodic changes are presumably produced, as is thought, by rotations upon their axes.

The second contribution on the form of the satellites appeared in the May number of the same journal for the following year, and Prof. Pickering opens with the statement that "what have appeared to be most natural suppositions have been found so frequently to be contradicted by the facts, that it seemed best to take nothing for granted with regard to them." The observations here deal first with the direction and period of rotation, giving as a result a probable retrograde motion of rotation for the first satellite.

With regard to the change of forms, it was noticed that the first satellite on January 13 appeared distinctly shortened equatorially when at its minimum phase, the phenomenon lasting thirty-four minutes; while the second satellite is occasionally described as appearing long, like the first. At the maximum phase the second, like the two outer satellites, has appeared round; and the third, at some of its minima retains the elliptical phase for a longer time than at others. Thus, for instance, it remained short for the three days, January 13, 14, and 15, consecutively.

The next account of further observations are contained in a long paper entitled "The Rotation of Jupiter's Outer Satellites," which appeared in the following June number. The observations here are given more in detail, but we will confine ourselves to the main points, commencing with those relating to the largest and most easily observed of the group, *i.e.* the third. This satellite, according to Prof. Pickering, presents an elliptical phase twice during its revolution in its orbit at an interval of about thirty-four hours after passing conjunction. When on the eastern side it presents an elliptical disc, and the inclination of the major axis to the orbital planes is clearly marked and has been measured on several occasions, the mean value being $-10^{\circ}\cdot5$ P. angle. We have here also some important observations of details visible on this disc of the satellite, which, as Prof. Pickering says, "can without much difficulty be made out."

A careful study shows that the marking usually appears forked, and is sometimes turned to the right and sometimes to the left, and at other times it is seen double, appearing like the letter X turned on one side. Another appearance of the markings on the surface of the same satellite is as if an equatorial belt on one side had been drawn out in both directions of the poles, its breadth increasing as the limb is approached, being in fact trumpet-shaped. A measurement of the position angle of the axis of the belt gave $+15^{\circ}\cdot5$.

Special precautions were taken to find out whether the belt were a genuine phenomenon, or an illusion due either to the instrument or the observer, but these resulted in it being declared real. The observations for the determination of the rotation of this satellite implied a period of rotation coinciding with that of the revolution of the satellite in its orbit.

A recapitulation of the facts relating to the third satellite observed up to this time may be made here:—

Two observers see the disc flattened at regular intervals, and agree upon direction of flattening. Both see a belt in same position, direction, and character of detail, and both remark that the observations are not very difficult, but quite evident when attention is called to them.

The details in the other satellites seem to be more difficult to see than those on the third. The direction of the bands (one or two) in the first satellite lies in an approximately north and south line, while on only one occasion there was detail detected on satellite II., and this consisted simply of a small patch or spot.

The observed facts with regard only to the forms of these discs are:—

The shape of the first is elongated. The regularly recurring changes of shape of the discs of the outer satellites (caused apparently by rotation). The change of position angle of the major axis of the third, and probably of the fourth in different parts of their orbits.

The peculiar behaviour of satellite III., which in October and November was recorded as shortened in the polar direction, but which was afterwards recorded upon two nights as perfectly round, when it should have exhibited its maximum ellipticity. The frequently recorded lengthening (equatorially) of satellite II., which is not corroborated by recent observation. Apparent irregularities in period and ellipticity of the second and, perhaps, the fourth, and the occasional irregular non-elliptical shape of the disc of the third.

Such, then, is the sum total of the observations which up to that time had been made by Prof. Pickering, and we will now turn our attention to the re-examination of the satellites by Prof. Barnard with the help of the great Lick refractor. (*Astronomy and Astro-Physics* for April, 1894).

He commences by telling us that the satellites I., III., and IV. often undergo singular transformations of apparent form during certain stages of their transits across the face of Jupiter, but he had never "seen any of these moons other than round when off the disc of the planet."

In the latter end of the year 1893 to the beginning of 1894, with a power of 1000 diameters, and sometimes higher, he made numerous observations, with the object of detecting, if present, deviations from the disc forms.

The results showed that no such deformations were observed, and Prof. Barnard is inclined to think that the surface markings of the satellites themselves, when near the edges of the discs, might readily cause apparent distortions in these satellites, as they certainly do so when the satellites are in transit, especially when very high magnifying powers on a small telescope are employed. It is curious, he adds, that such deformations should escape detection with our great telescope, even with the most casual observations, considering how conspicuous are the distortions recorded at Arequipa. It is of interest to note one or two remarks accompanying some of the observations, thus:—

		h. m.	
1893 ...	Dec. 3 ...	...	I. is near transit, following, it appears slightly elongated towards Jupiter.
1893 ...	Dec. 11 ...	9 18 ...	I., II., III., each is round, IV. seems a little deficient on following side, as if a slight phase existed, &c.
1894 ...	Jan. 28 ...	6 50 ...	I., II., III. are round, IV. is slightly deficient on following side, as if a slight phase or a dark area existed in it.

The time referred to above is Standard Pacific time, 8 hours slow on Greenwich.

The notes, however, are generally of the following type, a few of which may be mentioned here.

		h. m.	
1893 ...	Aug. 28 ...	14 30 ...	All four are round.
	Sept. 3 ...	13 0 ...	All four are round.
	Sept. 24 ...	12 48 ...	III. is perfectly round.
	Sept. 25 ...	15 0 ...	All four are round and clearly defined.
	Oct. 1 ...	16 40 ...	I. and III. perfectly round.
	Nov. 6	11 54 ...	III. is beautifully round.
		14 40 ...	III. is perfectly round.
	Dec. 10 ...	9 25 ...	All four are round. North Pole of III. is white.

These observations show that either the satellites on the whole appear generally round, or that the Lick observers have been so unfortunate as to observe them just at those times when the circular discs were to be seen. This seems at first thought to be very improbable, for the reason, as Prof. Barnard himself remarks, that the Arequipa observations indicate distortions that are apparently so very conspicuous.

In the June number of *Astronomy and Astro-Physics* (p. 423), Prof. Pickering gives in reply a short note to the observation made by Prof. Barnard. There are here, also, some measures of the position angle of the elongation of the first satellite as secured by himself and Mr. Douglas upon six different nights, a copy of which is below.

I. Satellite.

Time	P.A.	Dev.	Obs.	Diff.	Corr.
	°	°		°	°
1892, Nov. 28 ...	100·5	3·7			
,, ,, ...	108·3	8·7	P	+ 7·8	+0·7
Dec. 26 ...	100·0	7·6	D		
,, ,, ...	106·1	4·9	P	+ 6·1	− 1·0
,, 29 ...	103·8	5·0	D		
,, ,, ...	116·8	3·2	P	+13·0	+5·9
1893, Jan. 1 ...	90·0	6·0	D		
,, ,, ...	95·7	3·4	P	+ 5·7	− 1·4
,, 13 ...	99·2	4·2	D		
,, ,, ...	104·8	3·7	P	+ 5·6	− 1·5
,, 17 ...	92·4	3·8	P		
,, ,, ...	97·9	3·2	D	+ 4·6	− 2·5
		±4·8		+ 7·1	±2·2

Each measure is the mean of six readings, taken alternately in opposite directions. These measures show that the observations are fairly concordant, only that there seems to be a mean personal correction of about 7°·1. The first column gives the date of observation, the second the observed position-angle of the major axis of the disc, the third the average deviation of the readings which combined give the individual measures, the fourth the observers, the fifth the differences between these results, and the sixth these differences corrected by the constant angle 7·1.

In the last column, the mean 2°·2 indicates the average difference between the corrected measure of the two observers upon any night, which shows a remarkable accordance between the measures.

There can be no doubt that there was some peculiarity about this satellite that was under measurement at the time, a peculiarity which, as Prof. Pickering says, was apparent when it was not in transit, but which vanished at regular intervals of 6h. 32m. Why Prof. Barnard has not been able to witness what seems to be a very distinct phenomenon, if it be not really "personal," seems to raise considerable surprise. Although Prof. Pickering does not deny the existence of the equatorial belts, yet he will not accept it as an explanation of the changes of form noticed, for he says, "such a belt could not have produced the effects observed by us in Arequipa."

A further investigation on the forms of the discs has recently been made by Prof. Schaeberle (*The Astronomical Journal*, No. 321, p. 70), with the intention of detecting, if possible, the rapid change of phase which Prof. Pickering's observations so strongly advocate. The results showed, however, that, by tabulating the ratios of the measured major and minor axes of the several elliptical discs, a practically constant form for the outline was always obtained. We may mention here that to Profs. Campbell and Schaeberle the first satellite appears round only when "it is near to or projected on the disc of Jupiter, and elongated in the direction of the planet's equator in all other positions."

In judging between the weights that ought to be applied to observations made at Arequipa and Mount Hamilton, a fact here is mentioned that is by no means insignificant in showing the superiority, in this case at any rate, of the Mount Hamilton observations over those made at Arequipa.

The observations in question relate to the abnormal forms of the shadows of the satellites, the true forms of which were observed at the Lick Observatory by Prof. Schaeberle and by other observers at different places and times.

The shadows of these satellites as they pass before the disc of Jupiter become at times apparently distorted to observers on the earth's surface, owing to the oblique illumination of the satellites in some positions of the earth, and to the spherical nature of Jupiter's surface.

These distortions reach sometimes very considerable proportions, more considerable, in fact, than the changes of shapes of the satellites, as observed by Prof. Pickering. This being so, it is curious indeed that from Arequipa we have, as far as is known, no mention of such shadow distortions at all, and as Prof. Schaeberle remarks, "one would naturally suppose that an observer, after having discovered, as he believed, a periodic variation in the form of a satellite, would seek to verify his results by examinations of the satellite's shadow during its transit across the disc of the planet."

An idea of the size of the distortions alluded to may be gathered from Prof. Schaeberle's statements that, at the time of the Arequipa observations in January of last year, the longest (longitudinal) diameter of every shadow just after the ingress on the visible disc of Jupiter was "more than twice the breadth of the shadow, while at egress just the reverse condition of things existed."

Such, then, is the present state of affairs. Prof. Pickering sees these small bodies regularly changing their shapes; Prof. Barnard sees them always perfectly round; while Profs. Schaeberle and Campbell see them only round when near to or projected on the disc, and at all other times constantly elongated.

The only conclusion that can be drawn, if one is at liberty to draw any at all, is that in the estimation of the shapes of such small bodies a great amount of personal error is liable to creep in, and the estimation of such must be left for future determination.

It would be interesting, however, to know how the observations would differ, if Prof. Barnard and Schaeberle had the use of the Arequipa instrument at a favourable opportunity, and Prof. Pickering the Mount Hamilton refractor. W. J. S. LOCKYER.

GEOLOGY AND SCENERY IN IRELAND.[1]

MR. R. WELCH, of Belfast, well-known as a photographer of Irish scenery, has of late years utilised his intimate knowledge of the country, and his keen judgment as an artist, in the preparation of special series of photographs illustrating archæological and scientific features. The brilliant exposures of volcanic and sedimentary rocks along the coast of Co. Antrim have led him to form a group of pictures which might serve as a companion to any ordinary text-book of geology; and he is rapidly extending the series by additions from the counties of Down, Donegal, and even from the far south-west. As I have had the pleasure of assisting Mr. Welch in the production of his first geological catalogue, I can make no comment on its character as a publication; but I need not hesitate to point out what valuable aid is being given to science by the recording of the physical features of Ireland, not haphazard in a series of general landscapes, but with a special geological eye. The excursions of the Belfast Naturalists' Field Club have been the means of calling attention to exposures in places outside the ordinary tourist-track; and the officers of the Geological Survey of Ireland have always been willing to give information as to suitable illustrative localities.

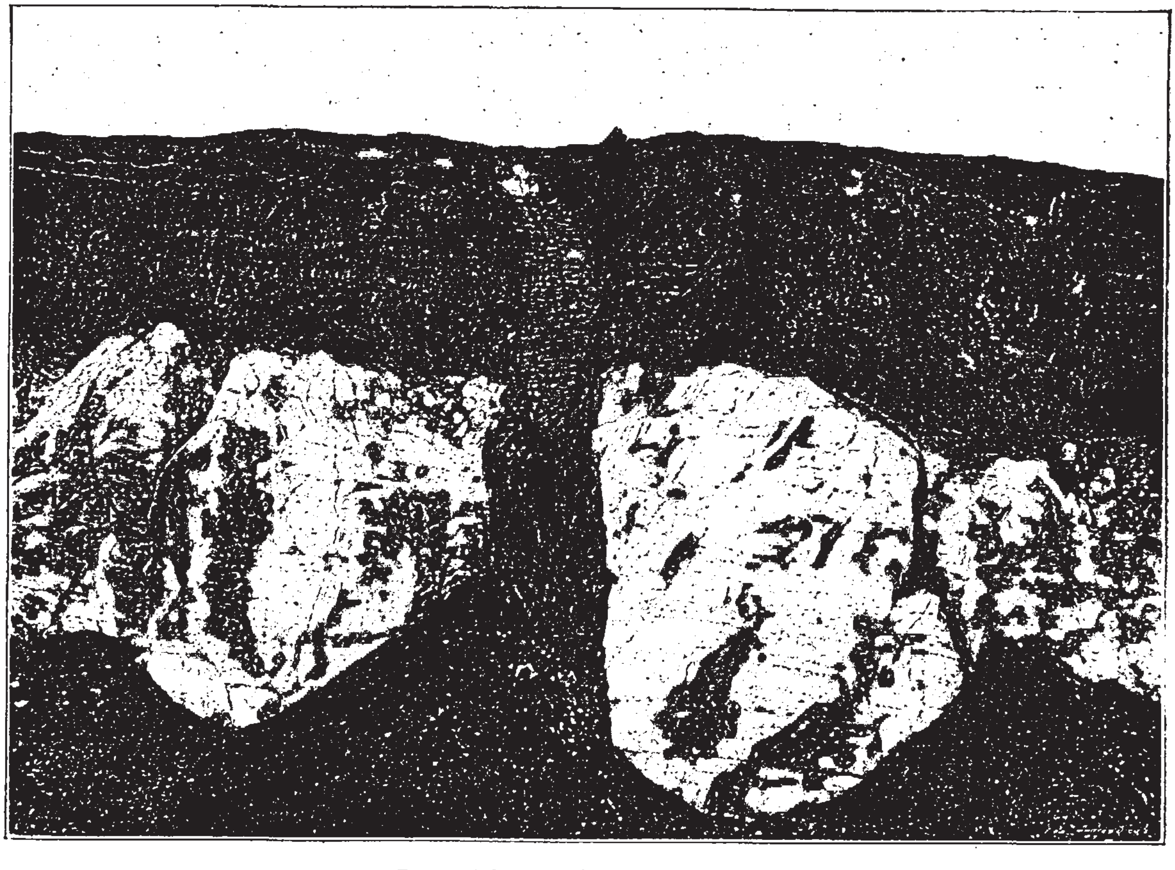

FIG. 1.—A Quarry Section on Cave Hill, Belfast.

Two samples will show something of the detail and the range of these photographic records. Fig. 1 shows one of the fine quarry-sections on Cave Hill, Belfast. The chalk below, with lines of flints, and the basaltic lavas of the upper plateau, are always an effective contrast; but at this point dykes of dolerite are numerous, cutting through both series. The large one in the centre of the picture is columnar in its upper portion, and has a somewhat wavy course. A smaller sinuous dyke climbs towards it from the right. In the left of the original photograph, a delicate bifurcating intrusive sheet is clearly seen near the top of the horizontal lavas. Fig. 2 is a still more specialised illustration. The whole stream of Glenariff is seen pouring into a pot-hole some four feet across, and the smooth sides of the hole, and the swirl of waters in its still active portion, have been admirably rendered. On the left, the rock, which is a red Triassic sandstone, shows the grooving and smoothing action of the stream. It would be interesting to photograph this spot again after an interval of twenty years.

The reproduction of such views as these in the form of lantern-slides makes them still more valuable to teachers. It is pleasant to know that Co. Antrim has its geological features now recorded for us more completely than those of any other county in the British Isles; and Mr. Welch may be congratulated on undertaking this and other scientific missions in the midst of more immediately popular professional work. The recent

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[1] A Catalogue of Geological Irish Views, by R. Welch, 49 Lonsdale Street, Belfast.